

Main Injector WQB Quadrupole

Meeting May 14, 2004

Pole radius	55.21 mm
Conductor	14.35 mm x 25.4 mm dia. 6.35 mm
Current	3600 A
MI Integrated Gradient at 500 A current	6.116501 T
at 3600 A current	43.703 T
Turns/pole	7
RMS current	2000 A

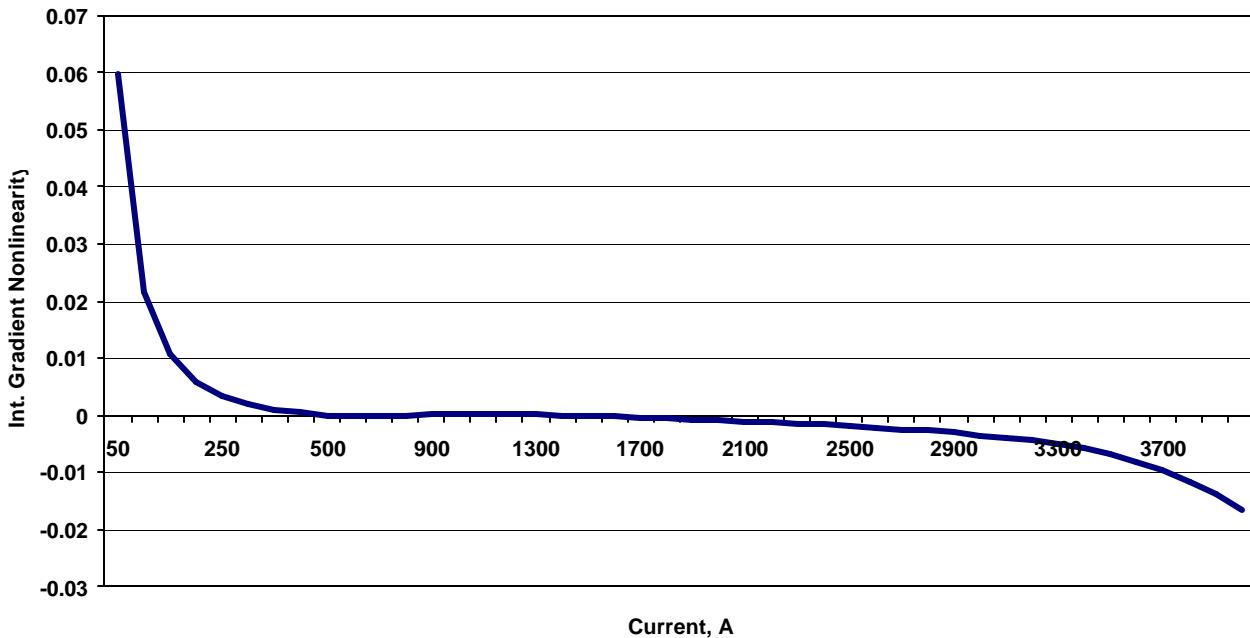
$$\text{Leff}(B) = \text{Lst}(B) + \text{Lends}(B)$$

MI Quadrupole Transfere Function Non-Linearity:

$$\text{ETA} = (G_2 * \text{Leff}^2 - G_1 * \text{Leff} * K_i) / (G_1 * \text{Leff} * K_i) = -7.6 * 10^{-3}$$

$$K_i = 3600 / 500 = 7.2$$

Transfer Function, Ref. at 500 A



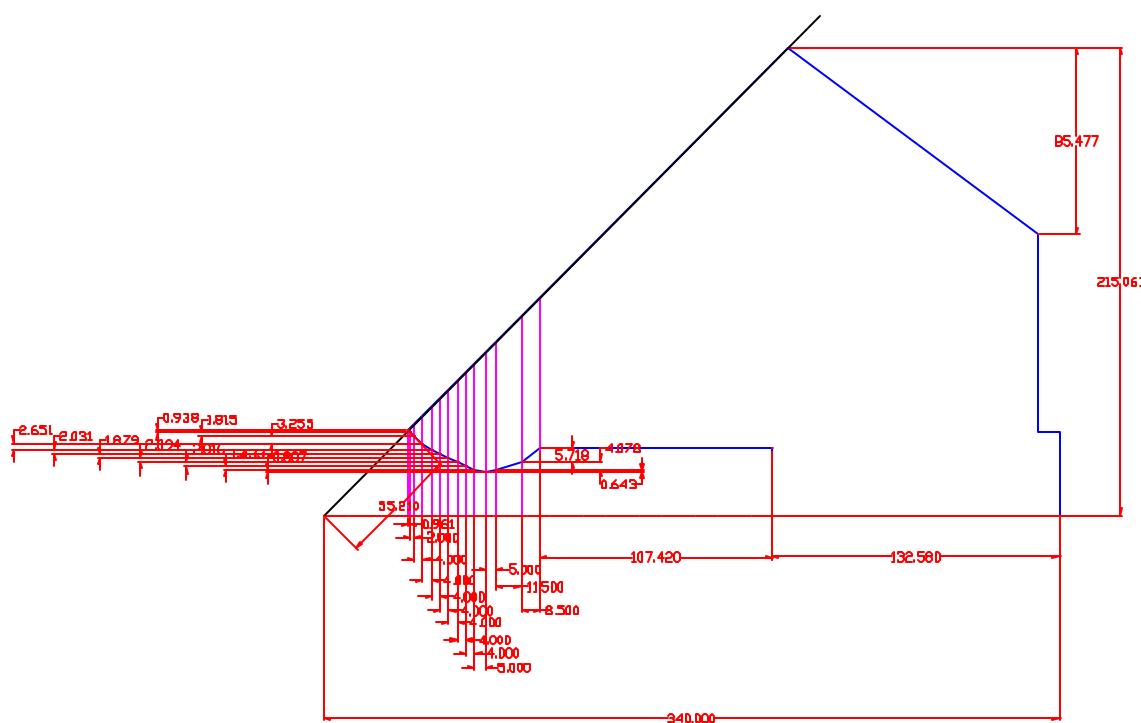


Fig.1. WQB lamination geometry

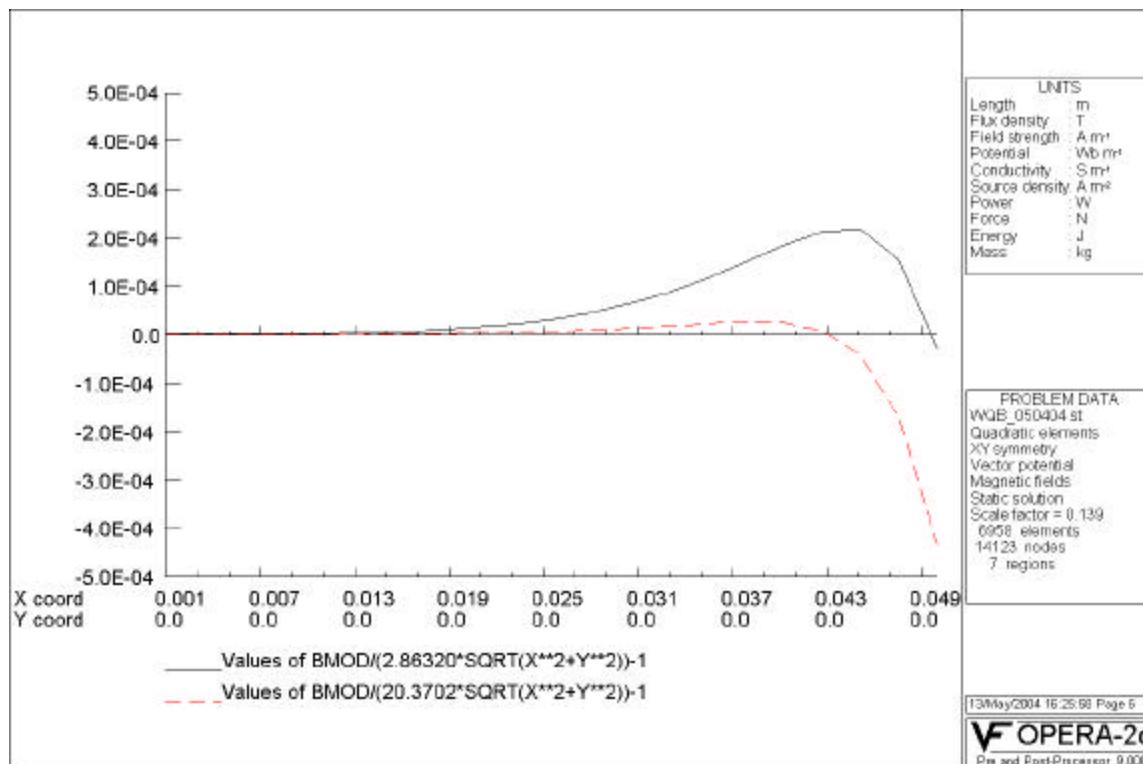


Fig. 2 Field non-linearity in the middle plane at current 500.4 A, gradient 2.863 T/m and current 3600 A gradient 20.3702 T/m, transfer function non-linearity – 0.011

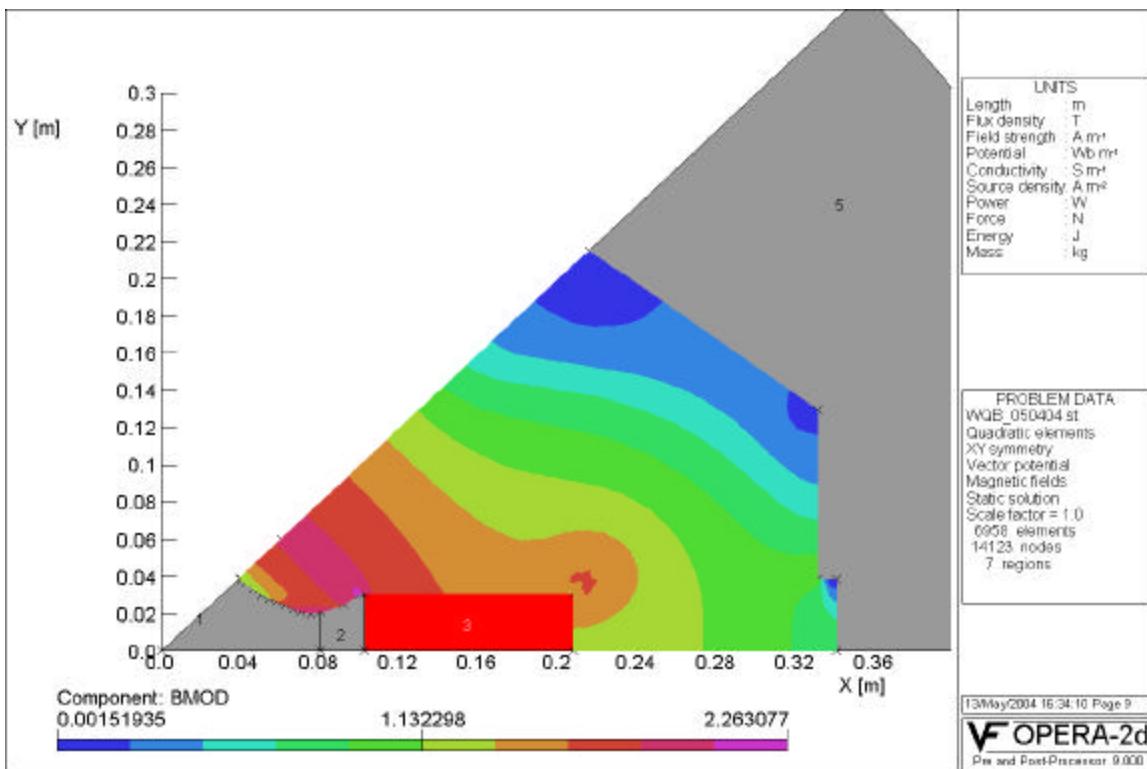


Fig. 3. Flux density at 3600 A current (7 turns/pole)

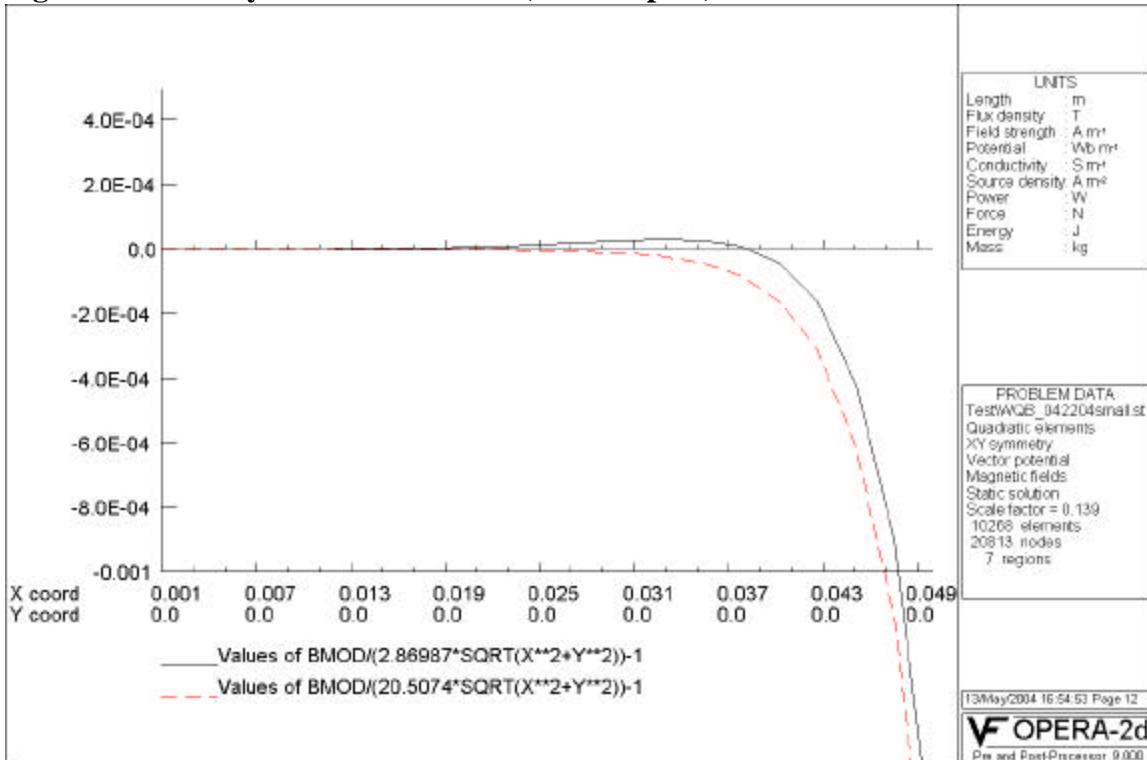


Fig. 4 Field non-linearity in the middle plane at current 500.4 A, gradient 2.87 T/m and current 3600 A gradient 20.5074 T/m, transfer function non-linearity – 6.74×10^{-3} , (6 turns/pole)

WQB 3D Magnetic Field Analysis

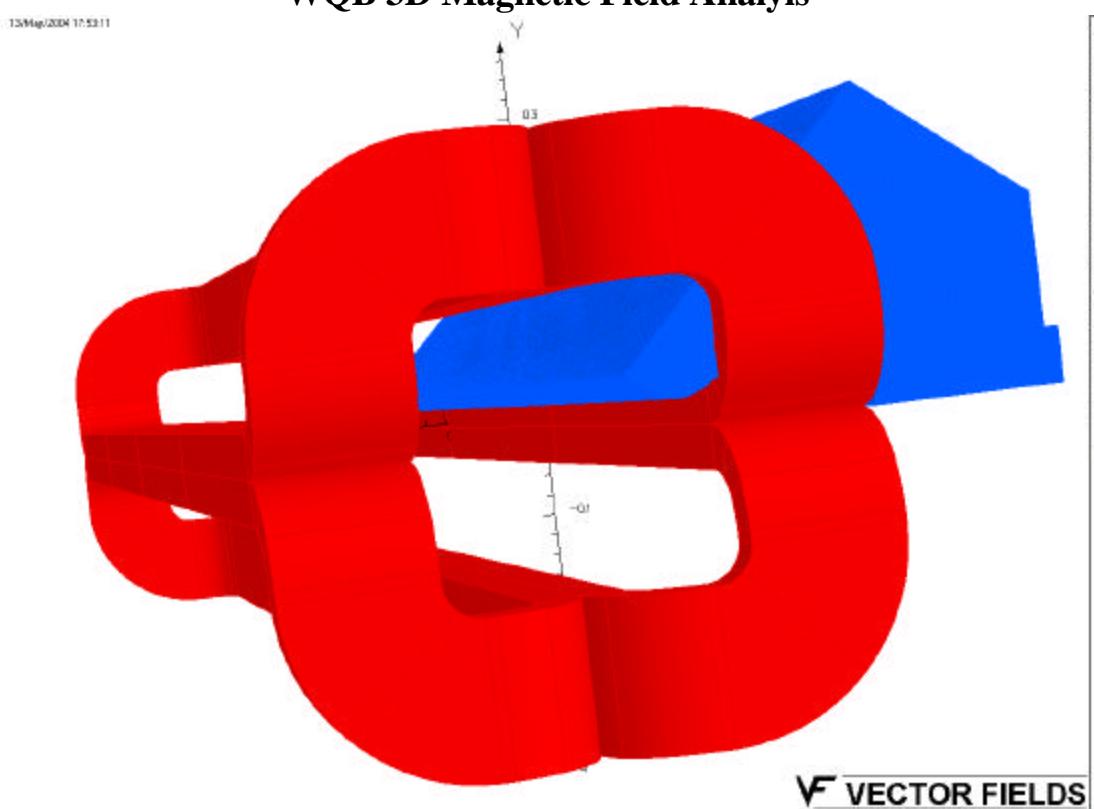


Fig. 5. Model geometry

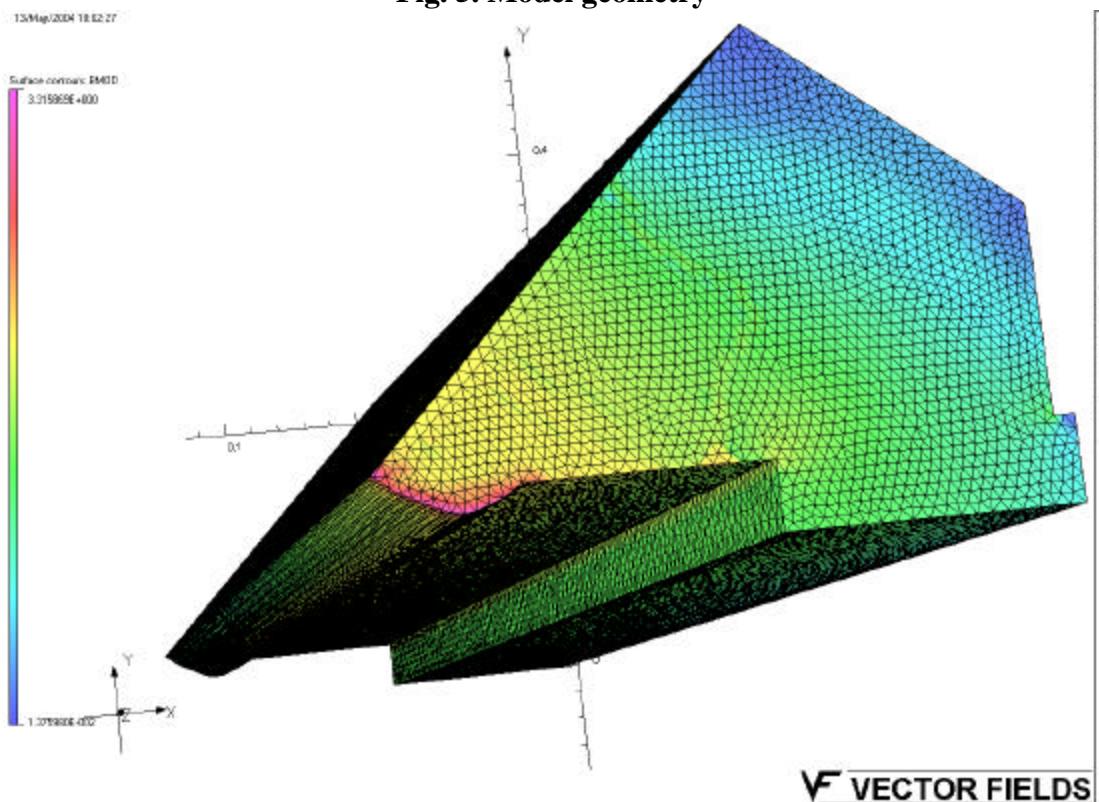
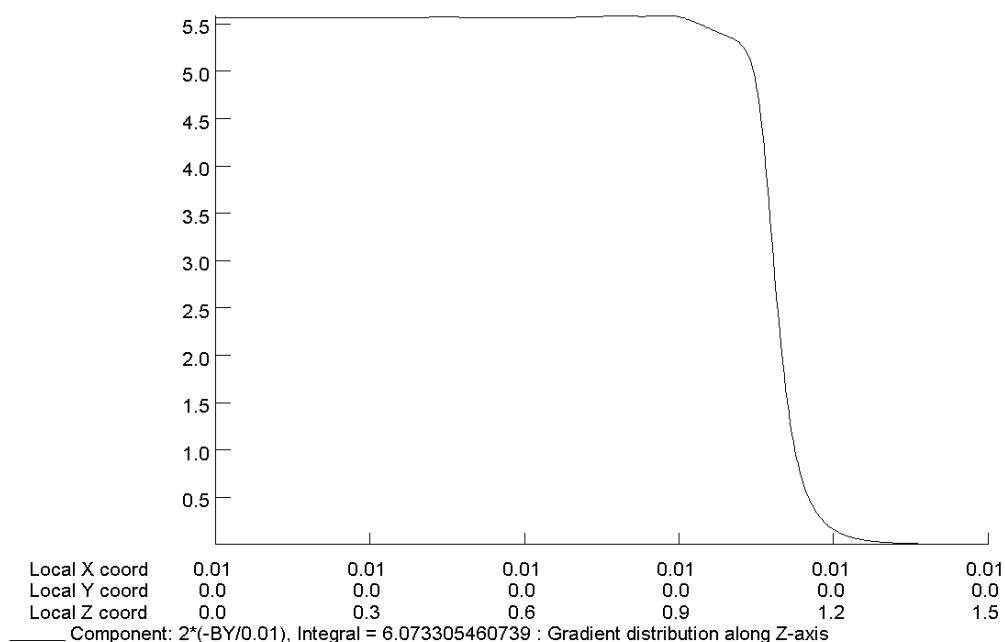
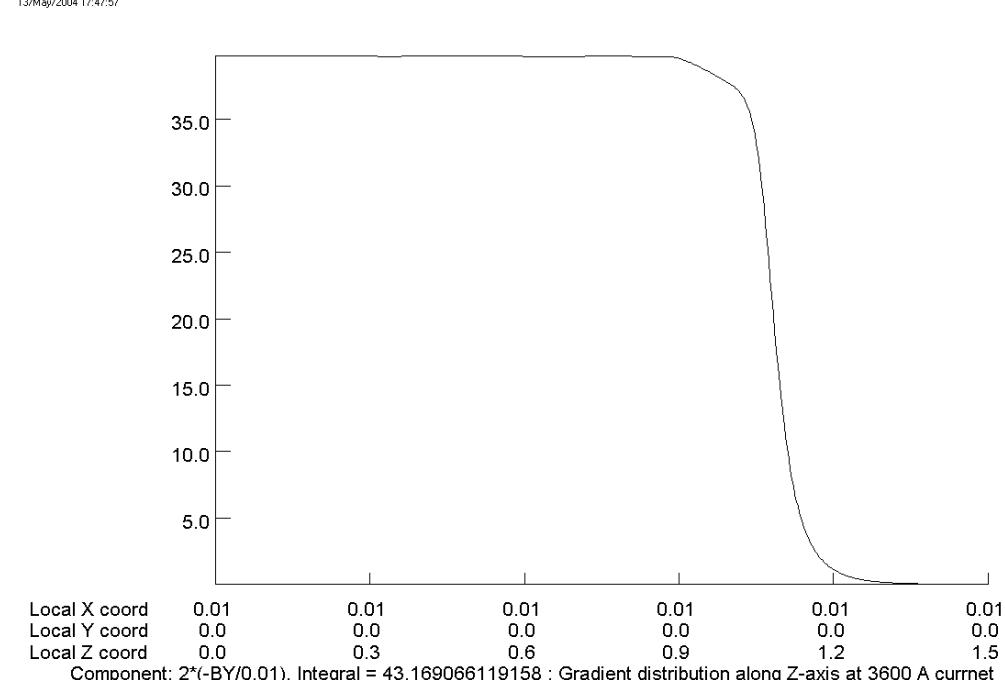


Fig. 6. Flux density distribution in the yoke

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**V VECTOR FIELDS****Fig. 7. Gradient change in Z-direction at 500 A current**

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**V VECTOR FIELDS****Fig. 8. Gradient change in Z- direction at 3600 A current
Transfer function non-linearity $-7.8 * 10^{-3}$**

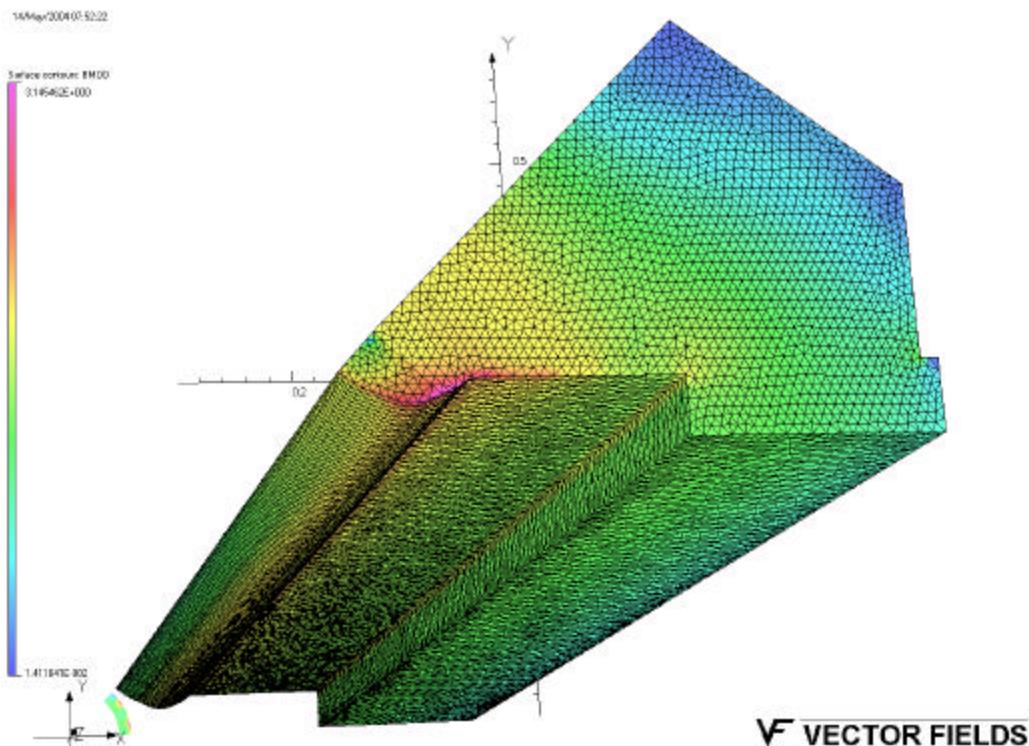
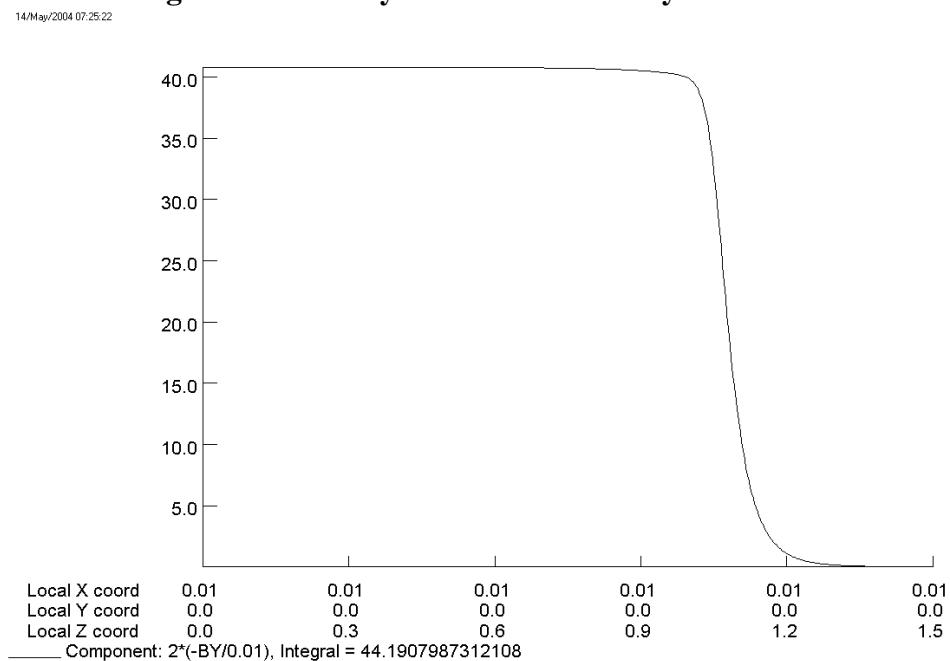


Fig. 9. Flux density distribution in the yoke with chamfer



VECTOR FIELDS

Fig. 10. Gradient change in Z- direction at 3600 A current (yoke with chamfer).

Central gradient 20.407 T/m. Integrated gradient 44. 191 T. Effective length 2.1655m.

Summary

1. It is possible to make quadrupole with 7 turns per pole and larger aperture.
2. The good field area larger than in quadrupole with 6 turns per pole
3. Larger also iron saturation effects and transfer function non-linearity.
4. The adjustable end shims should be included for effective length calibration.
5. The MI quadrupole central gradient should be measured at different currents.

Plan

1. Continue 3D calculations to improve tolerances.
2. Continue pole profile optimization.
3. Optimize ends configuration.